# Tone melodies in the age of Surface Correspondence

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Slides: cogsci.ucmerced.edu/shih/InkelasShih_CLS2015.pdf

## Tone

- The behavior of tone systems was a central motivation for Autosegmental Phonology (AP; Goldsmith 1976; Leben 1978)
- AP: a theory of phonological representations and rules operating over representations


- Designed around tone, then extended to the (tamer) behavior of vowels and consonants



## Tone in Optimality Theory

- Tone has played a relatively peripheral role in the development of Optimality Theory (Prince & Smolensky 1993)
- In the area of vowel and (especially) consonant harmony, AP has been supplanted by Agreement by Correspondence Theory (ABC), or Surface Correspondence (e.g., Hansson 2001, Rose & Walker 2004, Bennett 2013)
- ABC is segment-based; correspondence constraints refer to segments, not autosegments
- Where does this leave tone?



## This talk

- Uses Agreement by Correspondence theory and subsegmental Q theory (ABC+Q) to model the attested distribution of tone in Mende, a language originally thought to support AP representations
- Argues that ABC+Q provides a better account of a so-called tone melody language than a traditional AP melody account does

## Tone melodies

- The association of autosegmental tone melodies to tone-bearing units is a canonical example of what AP was designed to do
- Universal tone association conventions:
  - **Associate** tones to TBUs in a 1-1, L-R manner
  - **Spread** the rightmost tone to any remaining toneless TBUs
  - **Dock** any leftover tones to the rightmost TBU
- Obligatory Contour Principle: no adjacent identical autosegments

## Tone melodies

- The OCP and Universal Association Conventions team up to produce the famous Mende 5-way tone melody pattern (Williams 1971; Leben 1973, 1978) (also attested in Kukuya; Hyman 2007)

| Melody in UR | σ | σσ | σσσ |
|---|---|---|---|
| H | H | H.H | H.H.H |
| L | L | L.L | L.L.L |
| H L | H͡L | H.L | H.L.L |
| L H | L͡H | L.H | L.H.H |
| L H L | LH͡L | L.H͡L | L.H.L |

## Tone melodies

nyaha

L H L

1. L-R, 1-1 Association
2. Spread
3. Dock

hawama

H

## Challenges for melody account

- Mende has melodies beyond than the 5 canonical ones (Dwyer 1978)
- Melody complexity is correlated with word length
- The alignment of melody tones frequently violates the universal conventions (Dwyer 1978), forcing exceptional underlying representations (Leben 1978)

## Data: a Mende lexicon

- Data: 4,000 words from dictionary (Innes 1969)
- ~2,700 of the words are nouns (the category for which the AP melody analysis was said to hold)
- ~92% of nouns are 1–3 syllables long (*n*=2,493).
- Morpheme breaks not indicated, but the main source of morphological complexity in nouns appears to be total reduplication in 4-syllable words. We are not addressing 4-syllable words today.

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## Challenges for melody account

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## Tone melodies in the lexicon

- A search of the 2700 nouns in the Mende lexicon reveals many melodies. Disregarding alignment to syllables and just focusing on the overall contours of the melody, we find the following.

| | 1 | 2 | 3 |
|---|---|---|---|
| L | 25 | 251 | 25 |
| H | 53 | 531 | 101 |
| LH | 27 | 400 | 112 |
| HL | 31 | 243 | 127 |
| LHL | 9 | 276 | 204 |
| HLH | 0 | 6 | 22 |
| LHLH | 0 | 3 | 13 |
| HLHL | 0 | 11 | 12 |
| LHLHL | 0 | 1 | 10 |

Black indicates a melody licensed in the original AP analysis

Red indicates melody not predicted

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## Tone melodies in the lexicon

- Could add more melodies to the original AP account.

  H L LH HL LHL HLH LHLH HLHL LHLHL

- But: the AP account still misses the target on **melody complexity** and on **tone alignment**

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## Tone melody complexity

- Leben states: “By regarding the tone pattern as phonologically separate from the segments in these words, we capture the fact that a given pattern can occur regardless of how many syllables a word has” [Leben 1978:186]
- But: the corpus also reveals that the longer the word, the more likely a complex melody
- The independence of melodies in the original AP account does not predict this

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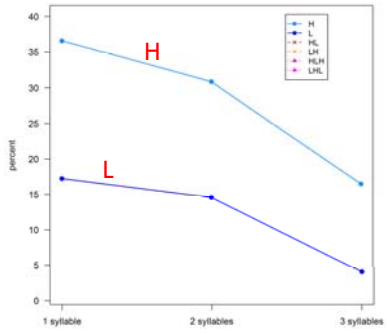
## Tone melody complexity

- Word length correlates with melody complexity




1-tone melodies

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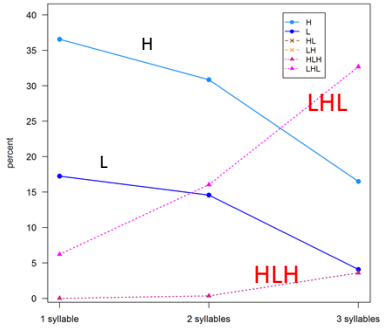
## Tone melody complexity

- Word length correlates with melody complexity more than would be expected in an AP approach




3-tone melodies

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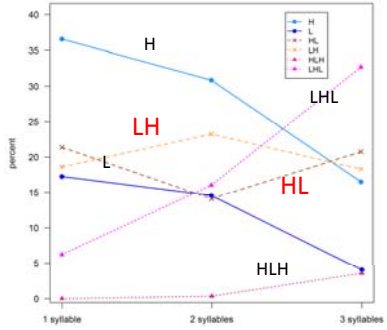
## Tone melody complexity

- Word length correlates with melody complexity more than would be expected in an AP approach




2-tone melodies

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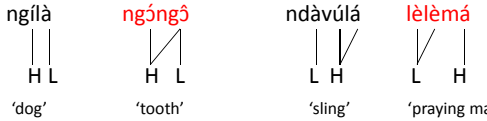
## Tone alignment

- Mende has melodies beyond than the 5 canonical ones (Dwyer 1978)
- Melody complexity is correlated with word length
- The alignment of melody tones frequently violates the universal conventions (Dwyer 1978)….

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## Tone alignment

- … forcing exceptional rules and underlying representations (Leben 1978)
- New association convention: a final H links to the final TBU
- Some H tones are exceptionally linked in UR


*H tones linked in UR to syllables where Association Conventions wouldn't link them*

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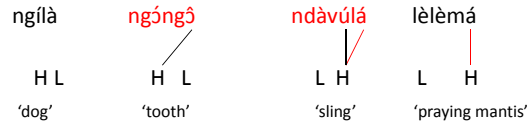
## Tone alignment

- … forcing exceptional rules and underlying representations (Leben 1978)
- New association convention: a final H links to the final TBU
- Some H tones are exceptionally linked in UR




*New, Mende-specific Association Convention links final H to final TBU*

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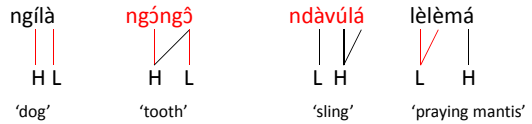
## Tone alignment

- … forcing exceptional rules and underlying representations (Leben 1978)
- New association convention: a final H links to the final TBU
- Some H tones are exceptionally linked in UR




*Universal Association Conventions do the rest of the work*

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## Tone alignment

- But the issue of unpredictable tone alignment goes beyond just these examples (e.g., Dwyer 1978, Conteh et al. 1983)



## Mende noun tones

| Syll | Melody | *n* | Syll | Melody | *n* | Melody | *n* |
|---|---|---|---|---|---|---|---|
| 1 | H | 53 | 1 | L | 25 | LH.L.H | 12 |
| | HL | 31 | | LHL | 5 | LH.L.HL | 8 |
| | LH | 27 | | LHHL | 4 | H.L.HL | 7 |
| 2 | H.H | 531 | 2 | LH.LHHL | 1 | LH.H.H | 6 |
| | L.H | 380 | | LHHL.H | 1 | HL.L.L | 5 |
| | L.L | 251 | | | | L.H.HL | 4 |
| | H.L | 212 | | | | LH.H.HL | 4 |
| | L.HL | 204 | 3 | L.H.L | 142 | LH.H.L | 4 |
| | LH.L | 64 | | H.H.H | 101 | H.LH.L | 3 |
| | H.HL | 17 | | L.L.H | 63 | L.L.LH | 3 |
| | HL.L | 14 | | H.H.L | 58 | L.HL.L | 2 |
| | LH.H | 13 | | L.H.H | 31 | | 1 |
| | HL.HL | 11 | | H.L.L | 31 | | 1 |
| | LH.HL | 8 | | L.L.HL | 31 | HL.H.HL | 1 |
| | L.LH | 7 | | H.H.HL | 25 | HL.H.L | 1 |
| | H.LH | 4 | | L.L.L | 25 | L.H.LH | 1 |
| | HL.LH | 2 | | H.L.H | 21 | L.HL.HL | 1 |
| | LH.LH | 2 | | LH.L.L | 17 | LH.LH.L | 1 |

*lèlèmá* pattern
*ndàvúlá* pattern



## A fresh look at tone

- Goal: instead of tone melodies and tone assignment rules, govern tone patterns via a set of correspondence constraints
- These constraints involve proximity and similarity
- **Claim: the resulting model better predicts the observed surface tone patterns in the lexicon, compared to the AP tone melody model**



## ABC

- Agreement by Correspondence (ABC) – originally developed for long distance consonant agreement, but since extended to vowel harmony and other local harmonies.
- ABC's purview: interactions between syntagmatic units.
- Key claim of ABC: units which are both sufficiently similar and sufficiently close to one another will correspond and thus interact.
  - Correspondence between elements which are similar yet not identical is unstable.
  - Assimilation and dissimilation are repairs for unstable correspondence.

## Q-theory

Key claim of Q theory (cf. Steriade's 1993 Aperture Theory): each segment ('Q') is decomposed into a small number of sequenced, featurally uniform subsegments ('q')

$Q(q^1\ q^2\ q^3)$

$V(v^1\ v^2\ v^3)$ $C(c^1\ c^2\ c^3)$

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## The tone-bearing unit (TBU) in Q-theory

- Contour tones in Q theory:

$V(H^1\ L^2\ H^3)$
$V(L^1\ L^2\ H^3)$
$V(H^1\ H^2\ H^3)$
*etc.*

- In Q theory, each q subsegment is featurally uniform
- "Contours" are Q's whose q's do not all agree tonally

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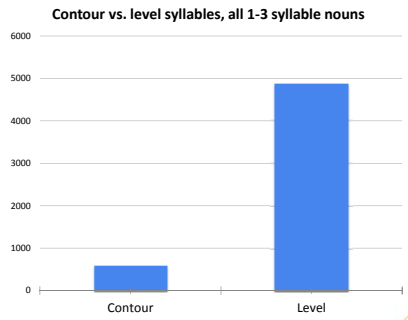
## Mende noun tone

Highly proximal q's (those within the same syllable) tend to agree in tone – contours are less frequent than level-toned syllables.

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## Tone in ABC+Q: correspondence under proximity and/or similarity

- **CORR-qq**
  q subsegments correspond & agree in tone
- **CORR-$[q::q]_\sigma$**
  Adjacent q subsegments within a syllable correspond & agree in tone
- **CORR-$[q_w::q_w]_\sigma$**
  Adjacent q subsegments within a nonfinal ('weak') syllable agree in tone

*NB: Scaling of proximity and similarity is standard in ABC*

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## Tone in ABC+Q

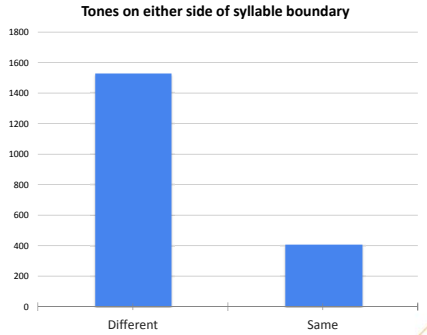
| | | CORR-$[q_w::q_w]_\sigma$ | CORR-q::q |
|---|---|---|---|
| ☞ a. | L.$\widehat{HL}$ (=$l_x l_x.h_y l_z$) | | 2 |
| b. | $\widehat{LH}$.L (=$l_x h_y.l_z l_z$) | W1 | 2 |

- CORR constraints penalize any change of tone across consecutive q's
- The penalty is higher if the tone change takes place within a (nonfinal) syllable



## Mende noun tone

In polysyllabic words with a complex (non-level) tone melody, it is more common for tone to change across than within syllables.






## Tone in ABC+Q: correspondence penalized across syllables

- **qq-EDGE σ**

  Adjacent q subsegments should not correspond across a syllable boundary

| | | | qq-EDGE σ | CORR-$[q_w::q_w]_\sigma$ | CORR-q::q |
|---|---|---|---|---|---|
| ☞ a. | L.$\widehat{HL}$ (=$l_x l_x.h_y l_z$) | 204 | | | 2 |
| b. | $\widehat{LH}$.L (=$l_x h_y.l_z l_z$) | 64 | | 1 | 2 |
| c. | $\widehat{LH}$.$\widehat{HL}$ (=$l_x h_y.h_y l_z$) | 8 | W1 | 1 | 2 |

*On Edge constraints, see Bennett 2013*



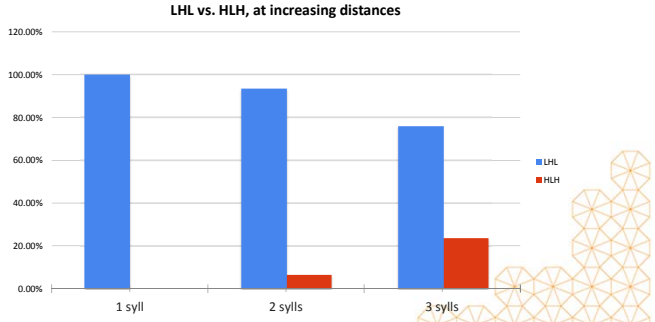
## Resulting prediction: tone melody complexity, # of syllables should correlate

| | σ σ | *freq* | qq-EDGE σ | CORR-$[q_w::q_w]_\sigma$ | CORR-q::q |
|---|---|---|---|---|---|
| ☞ a. | L.H (=$l_x l_x.h_y h_y$) | **380** | | | 1 |
| b. | L.L (=$l_x l_{x,y}.l_{y,z} l_z$) | 251 | W1 | | L |

| | σ σ σ | *freq* | qq-EDGE σ | CORR-$[q_w::q_w]_\sigma$ | CORR-q::q |
|---|---|---|---|---|---|
| ☞ a. | L.H.L (=$l_x l_x.h_y h_y.l_z l_z$) | **142** | | | 2 |
| b. | L.L.H (=$l_x l_{x,y}.l_{y,z} l_z h_a h_a$) | 63 | W1 | | L1 |
| c. | L.H.H (=$l_x l_x.h_y h_{y,z} h_{z,a} h_a$) | 40 | W1 | | L1 |
| d. | L.L.L (=$l_x l_{x,y}.l_{y,z} l_{z,a}.l_{a,b} l_b$) | 25 | W2 | | L |
| e. | $\widehat{LH}$.L.H (=$l_x h_y.l_z l_z.h_a h_a$) | 12 | | W1 | 3 |

## Mende nouns: a bias against HLH

LHL sequences outnumber HLH sequences – to a greater extent in a smaller span than in a larger span

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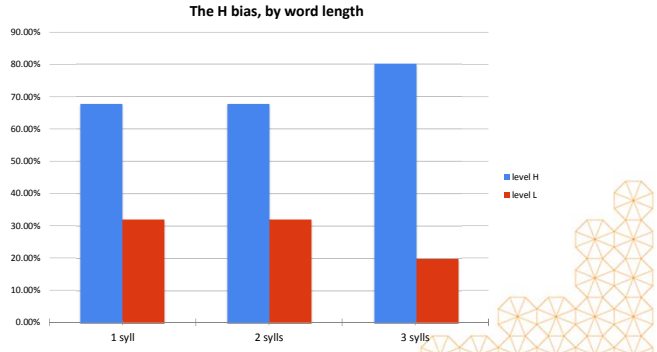
## Mende nouns: the H bias

All-H words outnumber all-L words

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## Capturing level H and LHL biases

- **HAVE-H**
  A word should have a H q subsegment
- **CORR-q[H]:∞:q[H]**
  H-toned q subsegments must correspond (at any distance)
- **q[H]q[H]-qADJ**
  Corresponding H-toned q subsegments must be adjacent

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## ABC+Q and AP-style analyses compared

**ABC+Q**

CORR-qq
CORR-$[q_w::q_w]_\sigma$
qq-EDGE σ
CORR-q[H]:∞:q[H]
q[H]q[H]-qADJ
HAVE-H

**AP, from 1970's**

ALIGN-R(H.H, L.L) "spreading"
ALIGN-R($\widehat{HL}$, $\widehat{LH}$) "docking"
(aka: CoincideCont)

OCP

**AP, updated**

*CONTOUR
*TROUGH (*HLH)
HAVE H

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## Comparing analyses

- Maximum Entropy Harmonic Grammar (MaxEnt) models (Goldwater & Johnson 2003; Wilson 2006; et seq.):
  - **ABC+Q**
  - **AP**
- fitted using maximum likelihood estimation in the MaxEnt Grammar Tool (Hayes et al. 2009).

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## Comparing analyses

- Input: number of syllables per word
- Output candidates: possible combinations of surface tone patterns

| **Input** | **Candidates** | | |
|---|---|---|---|
| σ σ σ | H.H.H | L.H.L | HL.HL.HL |
| | L.L.L | H.L.H | HL.HL.L |
| | H.H.HL | L.L.LH | HL.HL.H |
| | H.H.L | L.L.H | HL.L.HL |
| | H.HL.L | L.LH.H | HL.H.HL |
| | H.L.L | L.H.H | L.HL.HL |
| | HL.L.L | LH.H.H | *etc…* |

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## Comparing analyses

- MaxEnt ranks probabilities (i.e., comparative grammaticality) of outcome candidates in variable data.

$$\Pr(x) = \frac{\exp(-\mathcal{H}(x))}{\sum_{y \in \Omega} \exp(-\mathcal{H}(y))},$$

where $x$ = output candidate,
$\mathcal{H}$ = harmony score of a given candidate ($\boldsymbol{w} \cdot \boldsymbol{C}$), and
$y$ = possible output candidate in the entire candidate set $\Omega$ for a given input.

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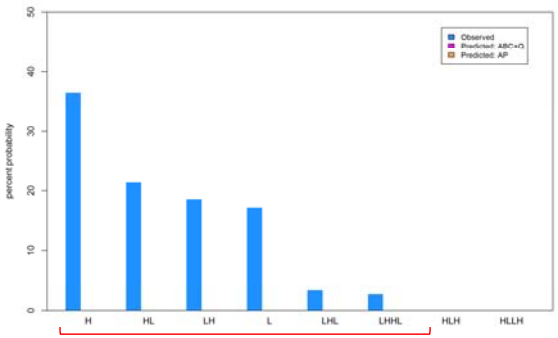
Results

## Predicted surface tone patterns

Surface tone melodies for 1 syllable words:

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Results

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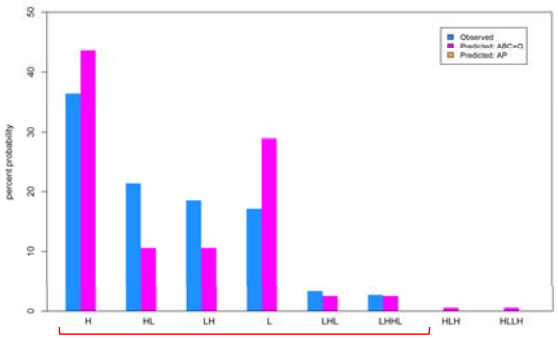




Results

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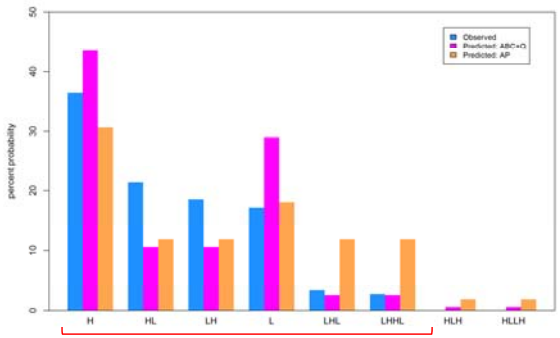





Results

## Predicted surface tone patterns

Top surface tone melodies for 1 syllable words:

*High Pr(x)* ↕ *Low Pr(x)*

| Observed | ABC+Q | AP |
|---|---|---|
| H | H | H |
| HL | L | L |
| LH | HL, LH | HL, LH, LHL |
| L | LHL | … |
| LHL | … | |
| … | | |

Top surface tone melodies for 2 syllable words:

*High Pr(x)* ↕ *Low Pr(x)*

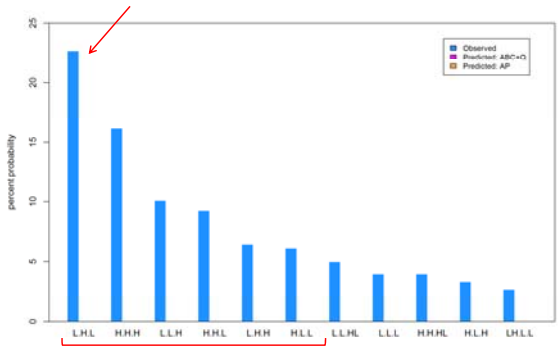
| Observed | ABC+Q | AP |
|---|---|---|
| H.H | L.H, HL | H.H, L.H, H.L |
| L.H | H.H | L.L |
| L.L | L.L | L.HL |
| H.L | L.HL | … |
| L.HL | … | |
| … | | |



Results

## Predicted surface tone patterns

Surface tone melodies for 3 syllable words:

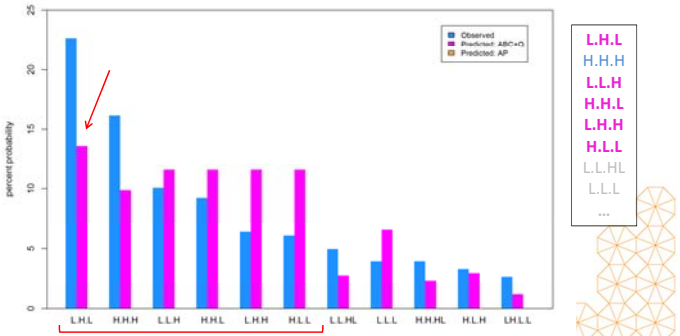



L.H.L
H.H.H
L.L.H
H.H.L
L.H.H
H.L.L
L.L.HL
L.L.L
…

Results

## Predicted surface tone patterns

Surface tone melodies for 3 syllable words:






Results

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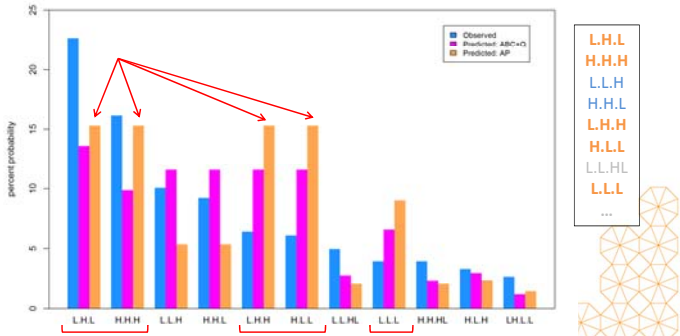




Discussion

## Alignment

- **Observed**:
  - L.L.H, H.H.L are more frequent than L.H.H, H.L.L.
    10.06, 9.27% 6.39, 6.07%
- **AP** analysis doesn't predict this:
  - Universal L → R association convention predicts the *opposite.*
  - Leben posited special rule + underlyingly linked tones to get L.L.H versus L.H.H, but these were supposed to be exceptional (and less frequent).
  - Cross-linguistically, tones tend to be R-aligned, rather than L-aligned (Cahill 2007).



Discussion

## Alignment

- **Observed**:
  - L.L.H, H.H.L are more frequent than L.H.H, H.L.L.
    10.06, 9.27% 6.39, 6.07%
- **ABC+Q** analysis doesn't predict any alignment differences (for now).
  - Delayed peak/transition likely arise from perceptual issues of tone
  - i.e., preferred site for tonal transitions might be as close to the final syllable boundary as possible.

Discussion

## H tone overattestation

- Models don't quite capture the full extent of the overattestation of level H surface patterns.
  - Potentially a multiplicative effect of Have H at each domain (word, syllable, segment).
  - Or a compounded effect licensed by the dispreference for H tones with intervening Ls.

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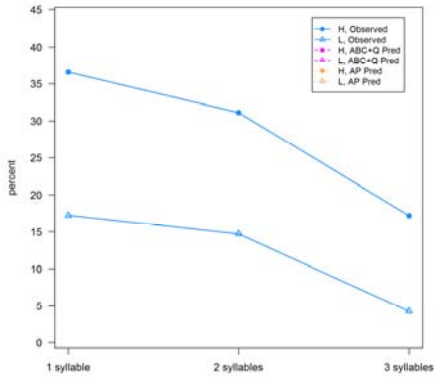
Discussion

## H tone overattestation




- However: the longer the word, the more likely the level H preference gets trumped by other factors, i.e., qq-EDGE σ.
- Predicted under ABC+Q account, not under AP.

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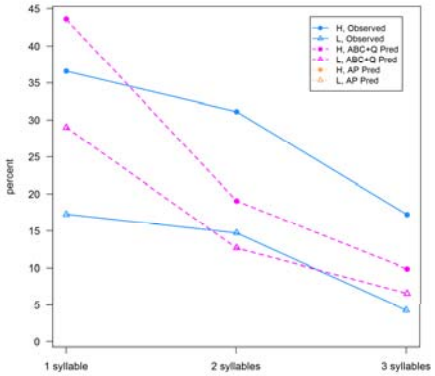
Discussion

## H tone overattestation

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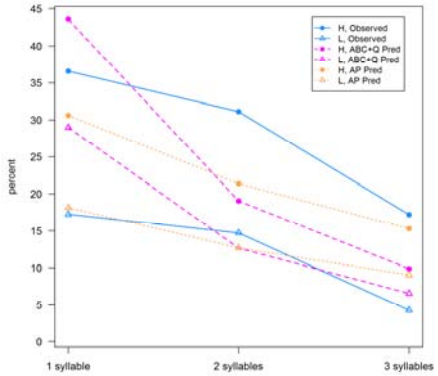
Discussion

## H tone overattestation

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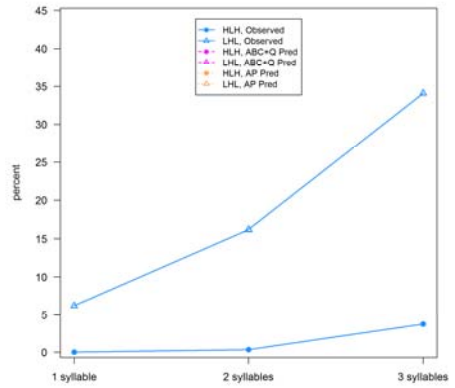
Results

## Complexity of surface tone patterns

Complex surface tone melodies (e.g., HLH, LHL):

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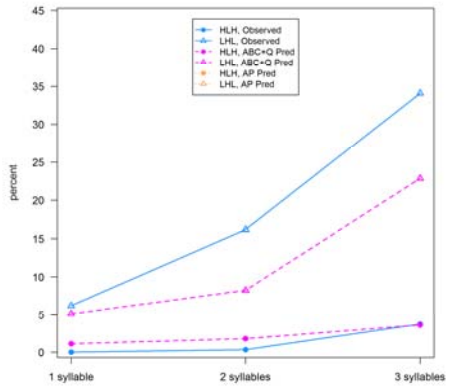
Results

## Complexity of surface tone patterns

Complex surface tone melodies (e.g., HLH, LHL):

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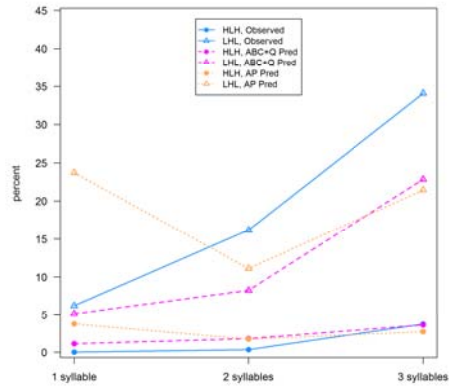
Results

## Complexity of surface tone patterns

Complex surface tone melodies (e.g., HLH, LHL):

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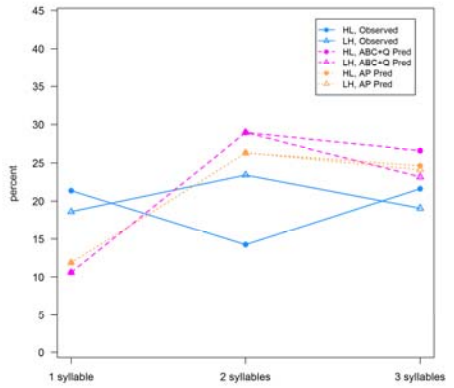
Results

## Complexity of surface tone patterns

Two-tone surface melodies (e.g., HL, LH):

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## Conclusion

- Examine surface tone melody patterns in classic "melody tone" language: Mende.
- Capture tone melody facts without recourse to representational mechanisms of AP.

- Proposed alternative: surface-oriented, correspondence-driven optimization in ABC+Q.
  - Based on general (potentially phonetically-grounded) properties of similarity and proximity interaction.
    ⇨ **ABC**
  - With representational "null hypothesis".
    ⇨ **+Q**

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## Conclusion

- Stochastic ABC+Q analysis predicts both lexical distribution *and* surface tone melody patterns.
- No need to *a priori* limit the melodic inventory.
  ⇨ Melody inventory is emergent from the grammar.

- In line with OT goal of a united analysis of morpheme structure constraints and phonological alternations.
- Melody inventory ≈ morpheme structure constraints

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## Conclusion

- ABC+Q does not need to make overt reference to melodic units.
- AP needs to reference contours and melodies as units, even though they're not supposed to be units.

- **Contours**
  - *CONTOUR achieved via CORR-q::q, where close proximity begets tone agreement.
  - COINCIDE(contour) achieved via CORR-$[q_w::q_w]_\sigma$, where close proximity within weaker prosodic positions begets tone agreement (i.e., less contrast).

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## Conclusion

- ABC+Q does not need to make overt reference to melodic units.
- AP needs to reference contours and melodies as units, even though they're not supposed to be units.

- **Melodies**
  - *HLH/*TROUGH achieved via qq-Limiter constraints (q[H]q[H]-$q_{ADJ}$)
  - Parallels in the segmental domain (e.g., Bennett 2013)
  - Provides a united analysis of tone plateauing (see Shih & Inkelas, in prep)
  - Similar subphonemic agreement work (e.g., Lionnet 2014)

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## Conclusion

- In ABC+Q:
  - similarity- and proximity-driven tone **agreement** captures contour and melody behaviors (contour, trough avoidance)
  - similarity- and proximity-driven tone **disagreement** captures scaling of melodic complexity with increasing number of syllables in words.

⇨ Single mechanism of **surface correspondence** underlies both effects.

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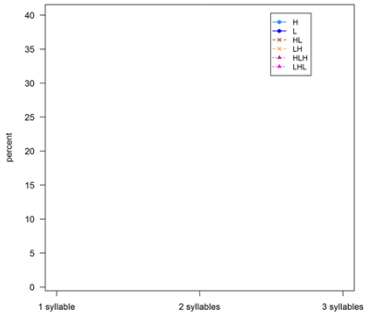
## Thank you!

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Slides available:
http://cogsci.ucmerced.edu/shih/InkelasShih_CLS2015.pdf

(References upon request)

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